Ergonomics Analysis of Blanket Lifting Technique Using Posture Evaluation Index Method in Virtual Environment

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Abstract— *Ergonomic analysis of blanket lifting technique using Posture Evaluation Index (PEI) Method in Virtual Environment. This research was conducted to study the ergonomic aspect of blanket/linens patient lifting technique in a virtual environment. Analysis phase was done using software Jack 6.1 which is one of ergonomic software that using digital human modeling technology. PEI was used as an approach that integrated results of three methods: lower back analysis (LBA), ovako working posture analysis (OWAS), and rapid upper limb assessment (RULA). The research objective is to analysis ergonomic aspects of blanket patient lifting process and to determine the most ergonomic posture during the patient lifting process. The ergonomic analysis only bed to bed blanket lifting process. The results show that the posture during lifting process had enough amount of risk that can injure the musculoskeletal system of the nurses. This research enriches the body of is the first research in Indonesia that applied virtual environment approach to ergonomics analysis in nursing process.*

Keywords—ergonomics, patient lifting, PEI, virtual environment.

I. INTRODUCTION

The healthcare industry becomes one of the workplaces that has a high risk of work-related disorders (WMSDs). Healthcare setting in Washington State report back injuries were the higher complaint among the nurses[1]. The lifting patient is one of an inevitable job of being a nurse. Lifting/forceful movement being the strongest indicators of WRMSDs. The risk becoming higher when nurses have a lack of knowledge about ergonomic posture during the patient lifting process.

WMSDs can lead to injuries to muscles, tendons, ligaments, and nerves and those that are severe can trigger career-ending injuries that entail surgeries [2]. WMSDs, including back injury, are perhaps among the most expensive, but most preventable workplace injuries in the United States [3]. The American Nurses Association (ANA) reports that physical injuries occur in nursing staff at a rate which is twice that found in the general working population [4].

Problems or injuries that take place when nurses doing patient lifting process are the backgrounds of this research. The purpose of this research is to determine an ergonomics lifting posture to reduce risks or injuries and increase comfortability. Repetitive action when doing patient lifting 4-5 times a day will cause fatigue or WMSDs (Work-related Musculoskeletal Disorders), which is related to other important parts of human body.

Digital Human Modeling (DHM) uses the accuracy of the biomechanics of the human body (based on gender and Anthropometry characteristics). Ergonomics analysis using the method DHM uses the help of software Jack specially designed to model and simulated human interaction with the environment and working tools.

DHM method is very successful in the automotive and manufacturing industry, but this method is very important in the health service. Nursing services have the work and activities that require complex posture on requiring the posture quite difficult or not ergonomic. To that end, DHM provides programs to investigate evaluate and demonstrate work scenarios in all industries as well as on the particular health services of patient lifting process as nursing services.

Using software Jack 6.1, we can make a simulation system that represents actual patient lifting activity. Software Jack development concerns about creating an accurate human model, the accurate dimension of posture and anthropometric data really represent real human, so the result of ergonomic analysis become more accurate and calculate Posture Evaluation Index (PEI) value using software Jack 6.1 to determine the risk of the patient lifting process [5].

Posture Evaluation Index (PEI) was used as an approach that integrated results of three methods: lower back analysis (LBA), Novak working posture analysis (OWAS), and rapid upper limb assessment (RULA).

II. METHODS

In this Study, Patient lifting movement is modeled by software Jack 6.1 with Posture Evaluation Index (PEI) method is the analysis technique. Software Jack 6.1 is one of ergonomics software that using digital human modeling technology with the result human anthropometric can be created accurately. Jack software uses biomechanically accurate human figures to be adapted in a virtual human who became the model for simulation.

Posture Evaluation Index (PEI) was used as an approach that integrated results of the lower back analysis (LBA), ovako working posture analysis (OWAS), and rapid upper limb assessment (RULA). PEI score depends on the level of discomfort of working postures. The following calculation of PEI score.

$$PEI = I_1 + I_2 + I_3.Mr$$

$$I_1 = \frac{LBA}{3400N} \; I_2 = \frac{OWAS}{4} \; I_3 = \frac{RULA}{7}$$

$$PEI = I_1 + I_2 + I_3.1{,}42$$

Description :

I1 : LBA score divided by 3400N
I2 : OWAS divided by its crisis score 4
I3 : RULA divided by its crisis score 7
LBA : Low Back Analysis score
OWAS: Ovako Working Posture score
RULA: Rapid Upper Limb Assessment score
Mr : Amplification Factor (1,42)

The level of discomfort a working posture resulting by score of the variable I1, I2, I3 and score of PEI. The PEI score shows the quality of a working posture, where the highest score among the various possible design configurations shows most un-ergonomic result and the lower score of PEI shows more ergonomic posture. PEI score has a minimum value of 0.47 (condition in which the working posture does not have the ergonomic problem at all) and the maximum value of 3.42. Then the variable is multiplied by 1.42 which is the amplification factor because in lifting posture using a backpack of the body have the upper body musculoskeletal injury risk greatest.

This study is a cross-sectional analytical survey to analysis ergonomic aspects of blanket patient lifting process and to determine the most ergonomic posture during the patient lifting process of 65 nurses in province general hospitals in Sumbawa, West Nusa Tenggara, Indonesia.

The first step is the observation field in do to observe directly about the condition or an overview of research location and to record the process of patient lifting by nurses. The process of patient lifting bed to bed was examined, because the bed to bed patient lifting is the most often performed by the nurses of Province General Hospital in Sumbawa, West Nusa Tenggara, Indonesia.

The second step is distributed of nordic body map questionnaire to find out which MSDs complaints were experienced by the nurses relating to the process of patient lifting. The nordic body map questionnaire given to the nurses who conducted the process of patient lifting. The questionnaire was conducted to find out the most MSDs complaints experienced by the nurses.

After conducted observations field in and the distributed of nordic body map questionnaire, the next step is measuring patient's bed as patient lifting process took place. Then, the anthropometry of nurses who performs a process of patient lifting is also collected. Measurements of anthropometry data include weight, height, standing elbow height, arm length top, the length of the forearm, shoulder, hip, high and high range top. The real Anthropometry data of the nurses is to carry out for the purposes of the creation of virtual human for simulation in a virtual environment using software Jack.

After all, data were collected, the last step is to make a simulation of patient lifting using the software Jack. In this phase, there are three processes: designing a three-dimensional of patient's bed model using Autodesk Inventor 3D CAD Software (see *Fig*. 1), building virtual environment of patient lifting place using software Jack, make simulation of patient lifting process with virtual environment and virtual human using software Jack (see *Fig*. 2), and calculate PEI score using software Jack 6.1.

After all the steps above, the data collections from the results of PEI score and score from the Nordic body map questionnaire were processed and analyzed using statistical tests by a computer program. The statistical analysis using a linear regression analysis to ascertain the influence of patient lifting posture toward MSDs complaints experienced by nurses of province general hospital of SSumbawa, West Nusa Tenggara, Indonesia.

III. RESULT AND DISCUTIONS

The result of Nordic body map shows that the highest complaint is the waist with the percentage of respondents who complained as many as 72, 3%. In addition, the back as many as 56,92%, the lower neck as many as 50,76% and the right shoulders as many as 47.69%.

The results of the simulation software jack show the minimum PEI score is 0.75 and the maximum score is 3.08. The maximum score that indicates that the lifting

postures is the worst posture (the most un-ergonomic work posture. The maximum score is the value from body bend position (see *Fig*. 3) and including the middle-low injury category. With the number of nurses with the category of not-injury as many as 13 nurses, categories of low injury as much as 31 nurses, the category of middle-low injury as many as 18 nurses and categories of middle-high injury by as many as 3 nurses. Based on the results of the calculation of the value of PEI can be seen that the process of patient lifting the nurse entered in the category of injury in several different categories. The injury category distinction because the nurses doing different positions on the process of patient lifting.

The result of statistic analysis using linear regression analysis to ascertain the influence of patient lifting posture toward MSDs complaints experienced by nurses shows that patient lifting posture has significant influence toward MSDs (see *Tabel 1*). The un-natural working posture of nurses caused by job demands and lack of tools for patient lifting process. The nurses only use blanket/linens to lift the patient from bed to bed. In addition, the nurses did not do the safe patient lifting techniques so lifting posture very bent. The research of Anap B. D, et al. (2013) [6] and Munabi i. G, et al. (2014) [7] report that the risk factors of work posture that may cause WRMSDs on nurse include lifting or moving patients and bending and twisting body posture. To transfer or lifting a patient, the nurses kneel on the bed, reach completely across, and pull. This requires even worse body mechanics.

The Standard Operational Procedure (SOP) of lifting and transferring patients is not available yet in Province General Hospital of Sumbawa is also become the main cause of un-natural work posture of patient lifting. The nurses do not have the guidelines of the safety patient lifting.

Based on The NIOSH Lifting Equation about Work Practices Guide for Manual Lifting was published in 1994, it recommended the maximum weight limit for use in patient-handling tasks is 23 kg (about 51 lbs.) [8]. When weight to be lifted exceeds this limit, assistive devices should be used.

Based on European Agency for Safety and Health about Patient handling techniques to prevent MSDs in healthcare, there are basic principles. Before starting any kind of handling activity, the caregiver should position himself as close as possible to the patient, also by kneeling on the patient's bed if necessary. This will enable the caregiver to avoid having to bend or stretch across the bed during patient lifting and transfer, thus making the necessary physical efforts while his back is bent or twisted. In this study, the most un-ergonomic lifting patient is bending the back because this posture has high PEI score among the other lifting posture. The simulation also make modification based on the basic lifting principle to make the position of virtual human as close as to the patient, so the nurse enables having to bend of the body during the lifting process (see *Fig*. 4). The simulation of using basic principle of OSHA lifting technique show that PEI score is decreased and the risk of MSDs also decreased. It means, if the nurses follow the safe lifting technique by OSHA or other safety organization, it can be reducing the number and the severity of MSDs due to patient lifting.

There are basic principles for adequate patient handling technique by OSHA to reducing the risk of MSDs. (1) Always seek the help of assistants where necessary; (2) Before starting any kind of handling activity, the caregiver should position himself as close as possible to the patient, also by kneeling on the patient's bed if necessary; (3) before starting any kind of handling operation, explain the procedure to the patient while also encouraging him to cooperate as much as possible in the course of the handling activity; (4) Keep a correct posture during patient handling operations; (5) Get a good grip during patient handling operations; (6) Wear suitable footwear and clothing [9].

Research and experience over than 30 years show that rely on a good body position or use a mechanical tool alone is not effective to decrease the MSDs risk. The comprehensive Safe Patient Handling program is Required. That is to communicate the commitment of management, employee participation, patient handing regulation, equipment mechanics, properly training and routine maintenance. The commitment and consistent to achieving goals and an effort to avoid incidents that cause injury to the patient or hospital worker is needed to lower the risk of MSDs [10].

Previous research supports ergonomics researches that are conducted using Virtual Environment, some of them used to design wudu place (Boy et al., 2013) [5] , Under-arm Lifting Technique (Chenyu et al. 2014) [11], Ergonomic Analysis of Garment Industry (Erlinda, 2011) [12].

IV. FIGURES AND TABLES

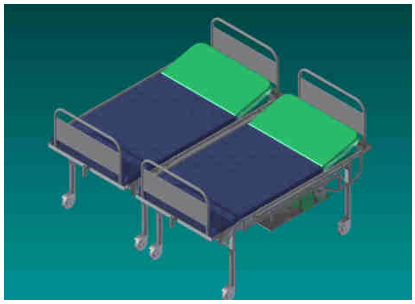

Fig. 1: A Three-dimensional model of patient's bed.

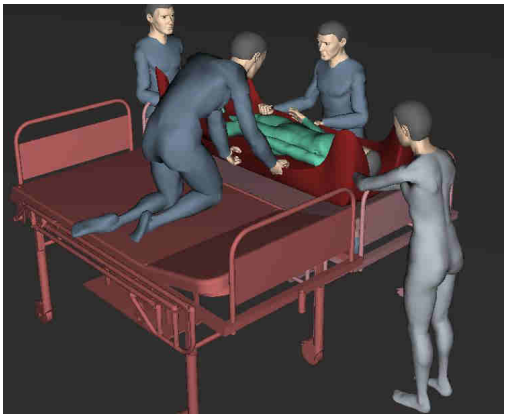

Fig. 2: A simulation of patient lifting process with the virtual environment and virtual human using software Jack 6.1.

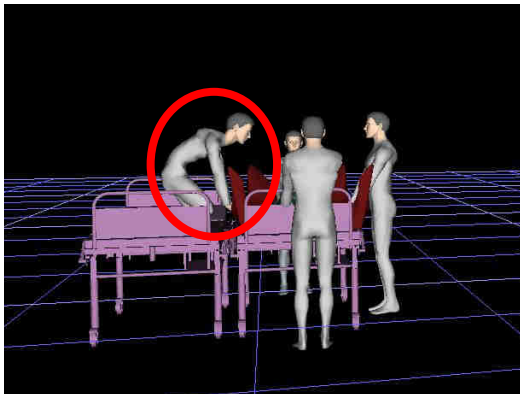

Fig. 3: The most un-ergonomic posture during the patient lifting process. The red circle is the most un-ergonomic lifting posture with high PEI Score.

Fig. 4: (a) The simulation using actual posture that the nurses did in the hospital. (b) The Simulation using basic principles by OSHA show that reducing the PEI score.

Table 1. The influence of PEI scores towards MSDs

	MSDs		Conclution
	Sig.	R Square	
PEI Score	0.029	0,059	Significant

Tabel shows the result of statistic analysis using linear regression. Sig. Value is 0.029 indicate that PEI Score of lifting posture has a significant influence towards MSDs.

V. CONCLUSION

Based on the simulation and the analysis, there are some conclusions that can be made :

1. The un-ergonomic lifting posture has a significant influence towards MSDs.
2. The maximum of PEI score is the score from body bend position and included in the middle-low injury category.
3. The nurses has to following the basic principles of patient handling techniques, so the number of MSDs due to patient lifting can be reduce.
4. To decrease the MSDs risk with the comprehensive Safe Patient Handling program. The commitment of management, employee participation, patient handing regulation, equipment mechanics, properly training and routine maintenancee.

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